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XVI.

CONTRIBUTIONS FROM THE CRYPTOGAMIC LABORATORY OF HARVARD UNIVERSITY.

XXIV.—VARIABILITY IN THE SPORES OF UREDO POLYPODII (PERS.) DC.

By B. M. Duggar.

Presented by W. G. Farlow, October 10, 1894.

Different opinions have been held as to the specific importance of certain forms of *Uredo* occurring on various genera of ferns. Likewise an uncertainty has existed relative to the twofold nature of the spores found in a single pustule. With a considerable amount of material representing several host-genera, to which I have had access through the kindness of Dr. Farlow, it has seemed of interest to give the subject careful study, hoping thereby to reconcile some of the views expressed.

Winter* has referred to *Uredo Polypodii* (Pers.) DC. all of the Uredo forms reported on many genera of ferns, the spores of this species measuring 19–52 × 12–22 μ. He distinguishes, however, a *forma Phegopteris,* on *Phegopteris,* based on the more or less polygonal character of the rather larger spores. Schroeter † includes under the same species the forms on *Cystopteris fragilis* and *Phegopteris Dryopteris,* recognizing, it seems, no essential differences for the forms on the two hosts. He describes the species in language resembling that of Winter, but with the exception that he mentions two kinds of uredospores respectively distinguished by thin and thick walls. It is suggested that perhaps the thick-walled spores are teleutospores. Dietel,‡ after examining some American and European collections, principally herbarium material, concludes that the differences in size of spores and the position of the sorus on the frond between the form on *Phegopteris Dryopteris* and the form on *Cystopteris fragilis* and other genera are sufficient to separate them. He would therefore refer the form on *Phegopteris Dryopteris* to *Uredo Aspidiotus* Pk.,* which is distinguished by having the sori on both sides of the leaf, but more abundant on the upper side; the spores are more or less polygonal or oval, measuring 36–56 × 27–40 μ, with from six to eight germ pores irregularly distributed over the surface. Dietel also emphasizes the constant appearance of thin-walled and thick-walled spores in both *Uredo Aspidiotus* Pk. and *U. Polypodii* (Pers.) DC. He mentions finding intermediate stages between the thin and the thick-walled spores, which seem to show that the one is developed from the other; but he entertains doubts as to which might be the primary form. Bearing in mind the suggestion of Winter as to the possibility of a teleutosporic form, he made cultures of the thick-walled type, yet the germination was that of true uredospores. It was then concluded that there were two kinds of uredospores in each of these species. It was also found that the thin-walled spores possess the constant character of four germ pores equatorially arranged, but this will be discussed later.

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* Rabenhorst, Kryptogamenflora, Pilze I. Abth. I. p. 253.

† Kryptogamenflora von Schlesien.

‡ Ueber *Uredo Polypodii* (Pers.), Oesterreichische Botanische Zeitschrift, XLIV., No. 2, February, 1894.

As far as I can ascertain, no views have been advanced as to the definite relationship of the thick-walled and thin-walled spores in regard to the relative time of development. For this purpose, as well as for a careful interpretation of specific distinctions, fresh specimens are essential. For the present study I was fortunate to secure from Arlington, Mass., fresh material of *Uredo Polypodii* (Pers.) DC. on *Cystopteris fragilis;* and at Shelburne, N. H., I found a supply of the form on *Phegopteris Dryopteris* described as *Uredo Aspidiotus* Pk. Access to an abundance of herbarium material, to be mentioned later, left no doubt as to the correct identification of the above named specimens. These two forms were carefully examined and compared in the fresh condition. In the form on *Cystopteris fragilis* the sori appear only on the under side of the leaf, and the spores are often smaller than in the case of the form on *Phegopteris Dryopteris,* but with these exceptions the general characters are the same. In either case, sections across the youngest sori show the thin-walled spores attached, and no thick-walled spores are present. The thin-walled spores are irregularly elliptical or oval (Figures 1, 2, 5, and 6), with very little trace of the orange contents. The whole number of germ pores is difficult to ascertain. In optical section one germ pore is often visible on each side about half-way between the apex and base, but more than one germ pore to a side is not infrequent, even in those spores possessing the thinnest walls. As I have stated, thick-walled spores are rarely to be seen in the young sori; but they are more abundant with the increasing age of the sorus, and the best defined of this type are always found unattached. These spores have orange-colored contents in the fresh condition. They are more or less oval in outline, with from four to eight germ pores generally indefinitely distributed over the surface, as in Figures 4, 8, and 10, taken from dried material. In every sorus showing both kinds of spores it needed little search to find connecting stages of every grade between the irregularly elliptical thin-walled spores and the oval or polygonal thick-walled spores. The cell wall is found in different degrees of thickness, and the number of well defined germ pores manifestly increases in proportion to this thickness of wall. Then from these results we derive the necessary conclusion that the thin-walled spores are merely the immature condition of the thick-walled mature uredo form.

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* Twenty-fourth Report of N. Y. State Museum, p. 88.

The herbarium material utilized in this study represented a number of host-plants, and the collections were made in widely separated localities; the diversity of material, therefore, should give a broad basis for reaching definite results. I have examined *Uredo Aspidiotus* Pk. on *Phegopteris Dryopteris*, Myc. Univ. 950, the material from the author of that species; also *Uredo Polypodii* (Pers.) DC. on the same host from Krieger, Fung. Sax. 566, Syd. Ured. 746, and a specimen collected by Dr. Farlow at Shelburne, N. H. I have studied specimens on *Cystopteris fragilis* bearing names as follows: *Uredo Polypodii* (Pers.) DC., Krieger, Fung. Sax. 567, and *Uredo Filicum* Desm., Erbario Critt. Italiano, 889; also material from Switzerland collected by P. Magnus and by Winter, and from Granville, Mass., Manitou, Col., Oregon, Gorham, N. H., and from near Boston, Mass. Other herbarium material included a specimen on *Phegopteris Dryopteris* from Thumen, Franconia, Germany; and *Uredo Polypodii* (Pers.) DC. on *Polypodium Dryopteris*, Eriksson, Fung. Paras. Scand., 70 b. I must admit that with the examination of only a few preparations of herbarium material I might be inclined to agree with previous writers in distinguishing two distinct kinds of uredospores, but the fresh material showed beyond doubt that the two forms are but different phases in the development. Likewise, this process of development was traced in all of the herbarium specimens above enumerated. Figures 1 to 8 inclusive show two series in which this development may be traced.

In view of Dietel's mention of the four germ pores equatorially disposed in the thin-walled spores, it was thought well to study this further; hence young sori were isolated, the spores cleared and stained.

The disposition of the germ pores thus made clearer is various, and I failed to find any constant number relative to any special zone. Figures 11, 12, 13, and 14 are examples seen. At most, a study of the germ pores of spores in such immature condition is unsatisfactory on account of the slight differentiation of the walls.

We may now proceed to a more detailed consideration of what may be the specific distinctions or likenesses in all of the specimens examined. It has been seen that the general characters of the mature spores are the same, the number and distribution of the germ pores varies within certain definite limits, and the process of development shows the same peculiarity — if one may term it such — of thin-walled and thick-walled spores. It remains for a comparison of measurements to lend weight one way or another. As Dietel's results would indicate, the form on *Cystopteris fragilis* is smaller than that on *Phegopteris Dryopteris,* but this did not prove entirely constant, nor is the average difference great. The following are the full limits of the spore measurements on the different genera: *Phegopteris Dryopteris,* Krieg. Fung. Sax. 566, 30–52 × 17–35 μ; Eriksson, Fung. Paras. Scand. 70 *b,* 24–40 × 16–35 μ; *Phegopteris Dryopteris,* from Germany, 26–40 × 18–24 μ; *Cystopteris fragilis,* 20–40 × 16–27 μ. One specimen on *Cystopteris fragilis* from Massachusetts measured 20–30 × 16–21 μ, while another specimen on the same host and from the same State gave 24–40 × 23–27 μ; thus the extremes on the same host showed a variation quite as marked as that characterizing the forms on different hosts. From these results it seems conclusive that these forms should all be referred to the same species, *Uredo Polypodii* (Pers.) DC.

The specimens on *Cystopteris fragilis* and *Polypodium Dryopteris* often show a slight roughness on the outer wall, and this character was more clearly seen in fresh specimens of the former. A *Uredo* on *Adiantum Capillus-Veneris* from Cavara, Fung. Longobardiæ, and one on *Woodsia glabella* from New Hampshire, have this roughened appearance; but the general characters of the spores seem undoubtedly those of *Uredo Polypodii* (Pers.) DC. The limited material hardly justifies a positive assertion. A Californian form on *Pteris aquilina* is distinctly echinulate, but in the general form and size of the spores it agrees with others studied. If it belongs to the same species at all, it is certainly an extreme form.* Fresh specimens are necessary for accurate demonstration.

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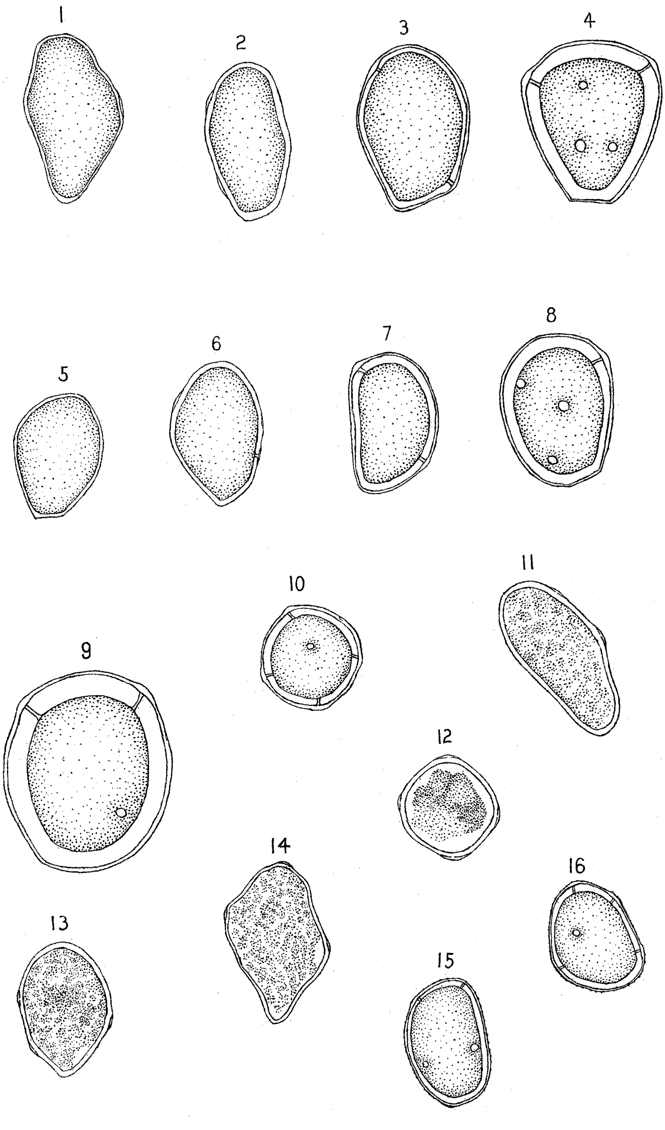
* Since the above notes were prepared for publication Dietel has described in Erythea, Vol. II. No. 8, [August, 1894,] *Uredo Pteridis* D. & H., on *Pteris aquilina;* and from his description it is plainly the form to which I have referred.

EXPLANATION OF THE PLATE.

All figures were drawn with the aid of an Abbé camera, using a Leitz objective No. 7 and ocular No. 3, reduced one fourth.

Figs. 1–4. Stages in the development of the form on *Phegopteris Dryopteris,* from Shelburne, N. H.
" 5–8. Similar stages as seen on *Cystopteris fragilis,* from Manitou, Col.
" 9, 10. Extreme sizes noted on *Phegopteris Dryopteris,* Eriksson, Fung. Paras. Scand. 70 *b.*
" 11–14. Immature spores on *Phegopteris Dryopteris,* cleared and stained, showing position of germ pores.
" 15. A spore of the form on *Woodsia glabella.*
" 16. From specimen on *Adiantum Capillus-Veneris.*



B.M.D. del.

Duggar on Uredo Polypodii.